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Genetics of resistance to early blight disease in crosses of wild derivatives of tomato

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ABSTRACT

The objective of this study was to determine the heterosis, inbreeding depression and genetics for yield, quality and resistance to early blight in tomato. Consequently, twenty inter-specific crosses of tomato were developed by crossing five susceptible cultivars and four wild resistant accessions and tested in field and glasshouse conditions for early blight (EB) resistance. Biochemical responses were also critically studied both in parents and hybrids. All the crosses showed moderately susceptible reaction except five crosses of EC-520061 (*Solanum habrochaites*). Biochemically the wild parents exhibited better results over susceptible parents but their hybrids showed moderate reaction for early blight resistance. High level of phenol was found both in resistant parents and hybrids. Among the 20 crosses, those made by EC-520061 and H-88-78-1 manifested resistance capacity, low heterosis and high inbreeding depression for EB disease. For yield associated traits most of the crosses expressed high heterosis and low inbreeding depression which indicated better yield capacity. The crosses made by EC-520061 (*S. habrochaites*) segregated in 3:1 (resistant:susceptible) Mendelian ratio and indicated monogenic dominant and additive gene effects. Remaining crosses showed 1:2:1 (resistant:intermediate:susceptible) genetic ratio and indicated heterozygous nature of crosses mediated by multiple genes or QTLs. This fact can be utilized in future tomato breeding program for developing resistant varieties against EB disease.

1. Introduction

Tomato (*Solanum lycopersicum* L.), is a global self-pollinated solanaceous crop (Foolad et al., 2000). Except being a rich source of antioxidants (especially lycopene and β-carotene) tomato fruits, are also fortified with vitamin A, vitamin C and other minerals like Ca, P and Fe (Saleem et al., 2013). India is the second largest tomato producer in world after China (Singh et al., 2015) and hence the crop has both domestic as well as global importance. In the recent times, F_1 hybrids have been in more demand over popular commercial varieties due to their excellent quality and high yielding capacity (Foolad et al., 2000). Early blight (EB), is a fungal disease caused by *Alternaria solani* (Ellis and Martin; Jones and Grout) comprising of collar rot on seedlings, dark leaf blight, stem necrotic lesions, and fruit rot with concentric rings (Fig. 1). This is one of the most important diseases which can affect the crop plant at any growth stage causing up to 75% yield losses (Kumar and Srivastava, 2013). A number of resistance sources against the pathogen have been reported in wild species, e.g., *Solanum habrochaites* (LA2100, LA2124 and LA2204), *Solanum pimpinellifolium* (EC521080), *Solanum peruvianum* (LA2157), and *Solanum chilense* (WIR5032) by Nash and Gardner (1988), Kalloo and Banerjee (1993), Poysa and Tu (1996), Foolad et al. (2000), Thirthamallappa and Lohithaswa (2000), and Singh et al. (2013) but they are yet to be harnessed in full potential against the pathogen (Foolad et al., 2000, 2008; Singh et al., 2013). However, in cultivated tomato the high levels of resistance to EB are limited except in few cultivars, i.e., PI-127805, PI-128216-1-2, PI-114968 and PI-276424, NCEBR-1, NCEBR-2, NCEBR-5, NCEBR-6, NC24E and NC39E, Ace, Flora Dade, Walter, Columbia, Red Cherry, CLN-2071-C, CLN-2070-A, BSS-174 and DTH-7 (Nash and Gardner, 1988; Pandey et al., 2003; Chaerani and Voorrips, 2006). The most probable reason could be the difficulty in transferring the resistant gene in target cultivars of tomato mainly because of physical barriers (Grigolli et al., 2011; Singh et al., 2014). Some moderately resistant hybrids and breeding lines have been developed such as Plum Dandy, Mountain Supreme, KNVFR, Taybioshinko, T-93, RS-912826 and Zenith (Chaerani and Voorrips, 2006) for early blight resistance. Heterosis breeding is a

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Fig. 1. Symptom of infected leaf, stem and fruits in tomato by *Alternaria solani*.

phenomenal tool to develop, potential hybrids in tomato both in the paradigm of yield and quality (Kurian et al., 2001; Ahmad et al., 2011). Breeding for resistance to insect pests and pathogensis one of the major challenges of tomato breeders. Usually the disease resistant hybrids were developed using inter-specific hybridization because wild species have characteristics to survive under stress conditions (Singh et al., 2014). Use of wild species of tomato is to be decreased in heterozygosity or increased in homozygosity of recessive deleterious alleles and indicated to inbreeding depression in the crops (Charlesworth and Charlesworth, 1987). However, the segregation in F_2 population indicated quantitatively inherited characters in tomato, which depended upon their parental morphology (Nash and Gardner, 1988; Singh et al., 2015). Further, many studies have been done regarding the inheritance of EB resistance using *S. lycopersicum*, *S. habrochaites* and *S. pimpinellifolium* which brought to the fore that resistance is a polygenically controlled quantitative trait (Nash and Gardner, 1988; Thirthamallappa and Lohithaswa, 2000). However, a monogenic, dominant inheritance (3:1 segregation) in *S. habrochaites* PI 134417 is also reported (Datar and Lonkar, 1985). The present investigation was undertaken with the objective, to study the heterosis and inbreeding depression for yield and quality traits as well as assess the inheritance pattern for early blight resistance in tomato.

2. Materials and methods

Nine diverse tomato genotypes were taken in which five were high yielder and susceptible cultivars of *Solanum lycopersicum* namely 'Co-3′, 'Punjab Chhuhara (PBC)', 'Kashi Anupam (DVRT-2)', 'Hissar Arun (Sel-7)', and 'DT-10′, each characterized by good shape and size of fruits while the rest four were resistant wild accessions viz., 'EC-520061 (*Solanum habrochaites*)', 'EC-521080 (*Solanum pimpinellifolium*)', 'WIR-3928 (*Solanum glandulosum*)' and 'H-88-78-1 (*Solanum lycopersicum* derivative of *S. habrochaites f. glaboratum*)' with high number of fruits. The wild accessions have already been reported resistant against early blight disease (Singh et al., 2012) the ICAR-Indian Institute of Vegetable Research (IIVR), Varanasi, India (latitude/longitude 25.10°N and 82.52°E, elevation 128.93 m.a.s.l.).

2.1. Development of F_1 hybrids and F_2 populations

Twenty inter-specific hybrids were developed by crossing between five susceptible and four resistant accessions in 'line × tester' mating design during October, 2009. These twenty-nine genotypes (20 F_1 hybrids + 9 parents) of tomato were considered for the experiment and evaluated in field during February, 2010. Harvested seeds of 20 F_1s were sown in nursery bed to produce F_2 seeds during October, 2010. Twenty-one days old seedlings were transplanted in two different conditions viz. field and screen-house (artificial) during February, 2011. In field conditions, 60 plants for each parent and hybrids and 210 plants of F_2s were transplanted in three replications. The standard agro-techniques were used without application of any pesticides to grow the healthy crops. For screen house studies, 500 earthen pots were filled with sandy loam soil (soil, sand and farm yard manure in 2:1:1 ratio) and kept in randomized block design, maintaining 10 plants for each parent, hybrids and F_2s. The temperature and relative humidity (RH) were maintained at 22 ± 2°C and 95%, respectively in screen-house.

2.2. Screening of parents, F_1 hybrids and F_2s

For screening against early blight disease, plants were examined after symptom expression at 45, 60, 75 and 90 days after transplanting (DATP) in field conditions and 7, 14, 21 and 28 DATP in artificial conditions (Pandey et al., 2003; Singh et al., 2012). Pure culture of virulent *A. solani* was grown on potato dextrose broth (PDB) in 500 mL conical flasks (Fig. 2) and uniformly sprayed on four-week-old tomato plants maintaining inoculum concentration of 125 cfu/mL (Pandey et al., 2003). The seedlings were kept in screen house and regularly fertilized with Hoagland solution (Singh et al., 2012).

2.3. Data observation and evaluation

The early blight symptoms were recorded on a scale of 0–5 as given in Table 1. The percent disease incidence (PDI) was calculated by using formula of Pandey et al. (2003).

$$\text{PDI} = \frac{\text{Sum of all ratings} \times 100}{\text{Total number of observations} \times \text{maximum rating grade}}$$

The horticultural data was observed from the middle rows of each replication. The observations were recorded for plant height (PH) in centimeter, number of primary branches (NPB), number of fruits per plant (NFPP), average fruit weight (AFW) in gram and fruit yield per plant (FYPP) in kg.